CORE COMPETENCES AND COMPANY PERFORMANCE IN THE WORLD-WIDE COMPUTER INDUSTRY

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This paper contributes to the understanding of the importance of dynamic firm capabilities for company performance in isolating the effect of the creation of core competences on the performance of companies in the international computer industry. It discusses and tests the assumed relation between different dimensions of core competences and performance. This is followed by a further study of the relation between the external appropriation of core competences through mergers and acquisitions, as well as through strategic technology alliances. A major conclusion of this study is that a specific set of endogenous technological core capabilities is needed to generate performance differentials. Also, the external appropriation of competences does not seem to be an easy solution through which companies can improve their existing capabilities in the short-run. © 2000 Elsevier Science Inc.

INTRODUCTION

In recent years the resource-based theory of the firm (Wernerfelt, 1984, 1995) and related contributions (e.g., Teece, 1982; Rumelt, 1984; Barney, 1986, 1991) focus on the importance of understanding company performance as a result of the efficient use of unique company capabilities that create sustained performance differentials within industries. Similar approaches are found in evolutionary economic theory (Nelson & Winter, 1982) and the theory of dynamic firm capabilities (Nelson, 1991) that analyze inter-firm differentials in terms of strategy, structure, and core

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capabilities. Other recent contributions stress the importance of down-scoping of firms in terms of refocusing of major activities to explain successful company performance (Hoskisson & Hitt, 1994; Hoskisson et al., 1994; Johnson, 1996), which we also understand as part of this more general attempt to study the effect of endogenous company capabilities on performance.

In the following analysis we will contribute to the understanding of the importance of dynamic firm capabilities for company performance in isolating the effect of the creation of core competences on performance in a technologically sophisticated environment. We apply a model that analyzes performance differences as a result of independent variables that are related to structure, strategy, and core capabilities or competences of firms.

In the literature the frequent use of the concept of core competences has not always run parallel to the further development of a clear definition. However, gradually the concept is becoming clearer and also more open to operational constructs for empirical research. Hamel and Prahalad (1994) describe core competences as " . . . a bundle of skills and technologies . . ."(p. 202). Markides and Williamson (1994) define core competences as a pool of experience, knowledge, and systems that together can act as catalysts that create and accumulate new strategic assets. These strategic assets, which are imperfectly imitable, constitute a firm's competitive advantage. Following Nelson (1991) core capabilities can be linked to a set of skills and search routines developed within firms. In addition to this, core competences can also be related to refocusing or specialization of companies in the context of a still rather broad set of capabilities (Hoskisson & Hitt, 1994).

In order to study the effect of core competences on company performance, our empirical analysis will be concentrated on one particular sector, i.e., the international computer industry. This strategic sector is well established with a tradition of international competition that has created a dynamic global environment with generally recognized competences that companies need in order to compete successfully. As this is a so-called high-tech industry these core competences can be expected to be related to technological skills that can differentiate between companies. It is also a sector in which one finds both diversified as well as more specialized companies competing in the same markets (Duysters, 1996). Another, more practical reason for choosing this sector is the relative abundance of reliable data for indicators on company performance, structure, and strategies. All this turns this sector into an interesting field for empirical research.

A problem for those interested in systematic empirical research is that frequently core competences are discussed for one or a few individual companies in which firm-specific lists of competences are generated that might be relevant in the context of each individual case (see Hamel & Heene, 1994) but that are difficult to translate to more generally applicable constructs. As our empirical research focuses on one sector we can systematically explore some of the different aspects of the still somewhat unclear character of the concept of core competences at an intermediate level in between the level of an individual company and the economy at large. For this exercise we can use operational constructs for core competences through a multidimensional measurement looking at a variety of indicators that one finds in the literature. Based on the relevance of research, skills and technologies, and focussed activities for understanding core competences and capabilities, the indicators we apply in this study are related to technological sophistication as well as

technological specialization and the degree of market specialization of companies. We also introduce two issues that are neglected in the literature but which are, in our opinion, critical to the understanding of core competences: the level of sophistication or "depth" of core competences and the "breadth" or degree of specialization of competences.

In addition to the analysis of the effect of core competences as endogenous capabilities, this paper also reflects on the possible effect of mergers and acquisitions (M&As) and strategic technology alliances that can be seen as major external and quasi-external means to strengthen existing capabilities (Dunning, 1995; Haspeslagh & Jemison, 1991; Helleloid & Siminon, 1994; Mowery et al., 1995). Because of the cumulative and tacit nature of technological knowledge, which is of particular relevance in so-called high-tech industries (Dosi, 1988; Dosi & Orsenigo, 1988; Nelson & Winter, 1982; Freeman, 1982), we assume that this kind of knowledge is often very difficult to transfer from one company to another and therefore cannot be acquired easily through market transactions (Mowery, 1988; Mowery et al., 1995; Osborn & Baughn, 1990). Both M&As and strategic technology alliances are alternatives to arm's-length transactions and enter into the arena of core competences if companies choose to externally search for means to cultivate their skills and capabilities further.

This paper starts off with an overview of major topics in the assessment of the role of several aspects of core competences that create differential company performances. In that particular section we will also introduce a set of hypotheses, derived from the literature, that will be tested empirically. The next section gives some insight in the model used to measure the effect of core competences, the variables and measures used, as well as a brief description of the population and the data. This is followed by sections in which we present the actual results of the analysis, a discussion of major findings and some conclusions.

EXPECTED EFFECTS OF ENDOGENOUS CORE COMPETENCES AND EXTERNALLY ACQUIRED COMPETENCES ON COMPANY PERFORMANCE

Technological Capabilities and Specialization as Core Competences

A number of recent contributions highlight the importance of technological competences, technical skills, learning, and knowledge developed within companies for understanding performance differentials (Hamel & Prahalad, 1994; Markides & Williamson, 1994; Nelson, 1991). Teece et al. (1994) and Robins and Wiersema (1995) point at the importance of coherence in corporate capabilities that strengthen the competitive advantages of companies. Robins and Wiersema (1995) found that multi-business companies with commonalities based on shared capabilities and know-how are associated with higher performance. Teece et al. (1994) stress the relevance of corporate coherence based on learning economies, reinforced by path dependencies, for understanding successful performance. Henderson and Cockburn (1994) mention "idiosyncratic research capabilities" as a major source of strategic competence that have a positive effect on company performance in high-tech industries. A common element that we find in all these contributions is the importance

of a proven track record in terms of well-developed skills in related technologies leading to a certain degree of technological specialization.

One of the more frequently used indicators that can help us trace the level of technological sophistication or specialization of companies is found in patent statistics. Patents are seen as an acceptable indicator for research output and proven technological competence (Patel & Pavitt, 1991; Cantwell & Hodson, 1991). As so many other indicators, this one is also subject to a debate regarding its usefulness (Cohen & Levin, 1989; Griliches, 1990; Archibugi, 1992), but it appears to be one of the more appropriate indicators that enable us to compare the technological performance of companies (Pavitt, 1988; Acs & Audretsch, 1989). Patents in general do indicate whether a company has been able to turn its research and other innovative activities into inventions that are worth protecting. As such this indicates the more general basic research skills and the past technological track-record of a company, which we propose to understand as the depth of the technological capabilities of a company.

We consider the breadth of a company's technological capabilities to be found in its technological diversification or reversely its technological specialization. In that context, the concentration of patents in particular areas of industrial activity indicates certain choices with regard to priority skills and concentrated innovative capabilities. In other words, the patent specialization of a company's activities expresses the established character of specific core competences and technological specialization in terms of the breadth of its research output and its technological skills. For both topics, i.e., the breadth and depth of these technological capabilities, we can formulate the following hypotheses:

H1: The degree of technological sophistication of firms (patent activity), as an important dimension of the depth of core competences, is expected to be positively related to their performance.

H2: The degree of technological specialization of firms (patent specialization), as an important dimension of the breadth of core competences, is expected to be positively related to their performance.

Refocusing of companies resulting in the specialization in specific industrial activities is also expected to be relevant for understanding the role of core competences, if this specialization is not taken in a too narrow understanding of small product-markets. The analysis of the role of market specialization is part of a long-lasting debate and controversy about the effect of diversification, in particular unrelated diversification, on company performance. It has to be stressed that this research on diversification and market specialization has generated a mixed bag of rather contradictory results. However, an increasing number of studies questions the more traditional view that the degree of overall diversification of firms is positively related to their performance. Current findings suggest that with unrelated diversification, implying incoherent and unrelated skills and knowledge within a company, it will be more difficult to benefit from economies of scope.

Research by Rumelt (1974) and Ramanujam and Varadarajan (1989) suggests that it is difficult to establish a positive relationship between the degree of (in particular unrelated) diversification of companies and their profitability. The recent contribution by Hoskisson et al. (1994) also indicates that the degree of companies'

diversification is related negatively to their performance. A stream of research has established that the degree of relatedness of lines of business is positively related to the performance of diversified firms (Wernerfelt & Montgomery, 1986; Varadarajan & Ramanujam, 1987; Ramanujam & Varadarajan, 1989; Capon et al., 1988; Harrison et al., 1993). This understanding of the role of relatedness comes close to our perception of market specialization in the light of core capabilities. In that context we understand market specialization as referring to broad product groups or industrial activities and not just one small market segment within an industry. An illustration of this is found in the international computer industry in which we relate market specialization to all activities in the industry at large, covering the whole range of computing and accounting machines and supporting activities and not just a small segment such as note book computers. Following this broad understanding of market specialization, we submit that:

H3: There exists a positive relation between the degree of market specialization of companies and their performance.

The Role of Externally Acquired Competences

As already mentioned in the introduction, M&As can be seen as instruments used by companies to externally acquire capabilities developed by their "partners" in order to complement existing core competences. This can have a positive economic effect on companies that are active in the M&A market. However, Meeks' (1977) overview of studies on the economic effects of M&As performed during the late 1950s and 1960s reveals that there is substantial ex post evidence that M&As have negative effects on the profitability of firms. Meeks' (1977) own empirical research suggests that in general there is a negative effect. Also research by Porter (1987), Ravenscraft and Scherer (1987), and Odagiri and Hase (1989) found no evidence that in general M&As improve the performance of companies.

In their recent contribution, Hoskisson and Hitt (1994) state that acquisitions may in general have negative effects on company performance as these acquisitions absorb too much attention from management; they also increase debt and they appear to multiply financial controls instead of stimulating the search for strategic opportunities. However, Hoskisson and Hitt (1994) also suggest that related acquisitions can have a positive effect on company performance if these acquisitions support innovative activities of firms. Previous research by Odagiri and Hase (1987) also found a positive albeit limited effect of related M&As on the profitability of firms. As related M&As are obviously more closely associated with existing core competences of companies than M&As in general, we could expect that:

H4: There exists a positive relation between higher shares of related M&As in the total number of M&As of companies and the performance of companies.

Apart from M&As, strategic technology alliances can also be used by companies to absorb new technologies from their partners or to jointly develop new innovative capabilities. Learning through alliances can complement endogenous learning to

create new competences (Kogut, 1991; Auster, 1992). The extent to which such strategies are successful is not always clear, for instance Hagedoorn and Schakenraad (1994) found no direct effect of strategic technology alliances on company performance in general.

Research so far indicates that the setting up of a wide variety of complementary strategic technology alliances with different partners has a more positive effect on company performance than a concentration of alliances in fields in which a company has already established considerable strength (Hagedoorn, 1993,1995; Harrigan, 1985; Mowery, 1988). This research suggests that complementarity is a major driver of partnering behavior. Therefore, a strategy aimed at creating a rather broad set of alliances that are complementary to endogenous capabilities could have a more positive effect on company performance than the formation of alliances that parallel existing capabilities. Thus,

H5: There exists an inverse relation between the concentration of strategic technology alliances of companies in their core industrial interest and the performance of companies.

Control Variables

Several control variables, discussed in the literature on company performance, technological capabilities, innovation, and specialization, could influence the relationships discussed above. Size of companies is expected to at least potentially influence each of these relationships. The survey by Schmalensee (1989) and recent research by Robins and Wiersema (1995) indicate that there is no direct effect of size of firms on company performance. However, Hoskisson et al. (1994) did find a positive effect of size on the performance of firms. Referring to the classical discussion in the innovation literature (Scherer, 1965, 1984) we expect that size of companies influences their patenting behavior. Also, size of companies can be expected to influence the degree of both market specialization and technological specialization.

Productivity is included in the analysis as we, following a standard economic line of reasoning, expect labor productivity differentials to have a positive effect on the performance of companies. As the international computer industry is gradually becoming more mature (IDC, 1988; Malerba et al., 1990; Forester, 1993; Duysters, 1996), we assume that although Schumpeterian innovative rents will still be important, productivity increases play a significant role in distributing economic results amongst competitors.

Finally, internationalization is one of the control variables because the literature on internationalization of companies, see Caves (1982) and Dunning (1993) for overviews of studies since the 1970s, suggests that internationalization has a, albeit marginally, positive effect on the profitability of firms. Hoskisson and Hitt (1994) state that internationalization, through the combined effects of markets, sourcing, economies of scale and scope, and increasing learning opportunities, has a positive effect on profitability. Caves (1982) and Dunning (1993) also indicate that international companies are more diversified in terms of product-markets.

DESCRIPTION OF THE MODEL, POPULATION AND DATA

The general outline of the model for the empirical assessment of the effect of core competence building on company performance is as follows:

$$p_i = f(\underline{c.c.}_i + \underline{e.c.a.}_i + size_i + prod._i + int._i)$$

where p is the performance of firms, c.c. are core competences (technological sophistication, technological specialization and market specialization), e.c.a. are external competence appropriation indicators of M&As and strategic technology alliances. The other independent variables are size of firms, the level of productivity, and the degree of internationalization. For the dependent variable, company performance, we take the average during the period 1991–1993, for the independent variables we take the period 1986–1990, introducing an average time-lag of several years.[1]

Variables and Measures

Company performance of each company in our sample is defined in terms of the average operating income to sales ratio for the period 1991–1993. It is known that the first indicator has certain drawbacks in particular in the context of sectoral differences and a comparison of manufacturing with service industries (Davis & Kay, 1990; Ansoff & McDonnell, 1990). As our present study refers in particular to one industry we can control for such inter-sectoral differences. We use operating income as an alternative to the often used net-income measure because operating income provides a more robust measure for corporate performance than for example net income[2] (Rees, 1990).

As an indicator for *technological specialization* (patent specialization) and the breadth of technological capabilities we use the ratio of the computer patent applications to total patent applications of each company for the period 1986–1990. We chose US patent office data because we expect the US market to be the most advanced in terms of the combination of competition, openness, and technological sophistication, in particular in information technology. We took the number of patents that firms applied for in SIC code 357 (computer and office equipment), which not only covers computers in a narrow sense but also includes peripheral equipment, storage devices, and terminals. We use a relative measure to account for the degree of technological specialization. Ratios close to 1 indicate that companies concentrate their patents mainly in computers, whereas ratios close to 0 indicate that most of the patents of companies are applied for other fields than computers.

For the indicator of *technological sophistication* (patent activity) and the depth of technological capabilities we use the total number of US patent applications of each company for the period 1986–1990 normalized by the size of companies.

Our third variable for core competences is the *degree of market specialization* of firms, indicating the share of computer sales in total corporate sales during the period 1986–1990. Values close to 1 indicate that the revenues of companies are almost completely derived from sales of computer equipment, whereas values close to 0 indicate that the computer revenues are only a small fraction of a firm's total revenues.

For *externally acquired competences* we use data on M&As and *strategic technology alliances* during the period 1986–1990. Instead of focussing on the total effect of M&As and strategic technology alliances on performance we concentrate on the effect of a specialization of these alliances and M&As in the field of computers on corporate performance. The computer alliances to total alliances ratio and the ratio of computer M&As to total M&As are used to determine the degree of specialization in the external appropriation of competences. Again values close to 1 refer to a specialization of M&As and strategic technology alliances in computers whereas values close to 0 indicate that the far majority of their alliances and M&As can be found outside the field of computers.

As discussed there are three control variables. *Size* of companies is measured by taking the log of average computer revenues that companies realized during the period 1986–1990. We have chosen revenues as an indicator instead of the more frequently applied employment indicator to account for quasi-integration. It is well known that Japanese companies have fewer employees than their US and European competitors on account of the Japanese lean production practice and sophisticated customer-supplier networks. However, their size in terms of revenues, which roughly equals turnover, is in our opinion a better indicator of their economic magnitude in comparison with companies from other regions. *Productivity* is measured as the computer employment to computer sales ratio for each firm during the period 1986–1990. As an indicator of *internationalization* of companies during the years 1986–1990 we employ the percentage of sales that were accumulated outside a firm's home region. We distinguish three home regions, i.e. the United States, Europe, and Japan.[3]

Population and Data

Our analysis refers to a group of 57 companies that together build the core of the international computer industry. We estimate that these companies together represent about 75% of the international computer industry.[4] Of the 57 companies in our sample, 36 are based in the United States, 7 are European, and 14 in Japan (see Annex I).

Data for all variables, with the exception of those related to patents, M&As, and strategic technology alliances, were taken from several issues of Gartner Group's annual Yardstick Top 100 Worldwide covering the period 1986–1993. The Yardstick Top 100 Worldwide is an authoritative statistical review of the information processing industry comprising the top 100 international vendors worldwide that was published until 1994. Data in the Yardstick was updated annually through surveys and research by Gartner Group consultants and industry analysts. When data was missing estimates were taken from industry analyst input and from other available industry sources. These estimates were primarily made for privately held company information. The Yardstick contains calender year information, as opposed to information based on fiscal years, which allows us to make better comparisons between companies. Also, the Gartner data is adjusted for differences in currency exchange rates.

The data on patents was taken from the US Patent and Trademark Office database (US Department of Commerce). Data on M&A specialization was extracted from SRI Securities Data's M&A database. This data bank is property of

TABLE 1
Regression estimates of the influence of core competences and other key variables on company performance in the world-wide computer industry, n = 57

Variable	*Beta*	*T*
Constant		1.58
Technological specialization	0.431	2.15**
Technological sophistication	0.09	0.56
Market specialization	−0.507	−2.13**
Mergers and acquisitions	−0.017	−0.1
Strategic technology alliances	−0.082	−1.63
Size	−0.386	−1.80*
Productivity	0.137	0.91
Internationalization	−0.084	−0.52

* $p < 0.10$
** $p < 0.05$
$R^2 = 0.387$ Adj $R^2 = 0.229$ Std Er = 0.084 F = 2.4485 Sign. F = 0.0351

the firm Securities Data and can be used via on-line access. This information is arranged in several data files. For a limited period of time this database has been accessed and a specific data sample has been extracted. The relational form of the database facilitates the linking of these data files to each other and also to files in other data banks. Within the M&As data base there is information on the year the M&A got established. In addition, it contains company information on the acquirer, the target, the parent acquirer, and the parent target firm. The industry information is provided in SIC codes of the aquiree and acquirer. Unfortunately, the distinction between a merger or an acquisition as made by Securities Data does not always correspond to the actual background of the M&A. This is partly due to the character of information on M&As in the trade literature. For example, a number of cases has been classified as mergers despite the obvious mismatches in firm-size indicating an acquisition. Acquisitions are frequently presented as mergers because of the negative publicity that acquisitions receive in particular if a foreign partner is involved. Also, the official classification and definition of both modes differs from country to country (Milgrom & Roberts, 1992). As M&As both lead to integration they are taken together and considered as one single category.

Finally, all the data regarding strategic technology alliances was taken from the CATI database. The MERIT-CATI data bank contains information on thousands of cooperative technology agreements and their "parent" companies. The alliances in the database are primarily related to technology cooperation. Mere production or marketing agreements are therefore excluded. The information on strategic technology alliances in this database covers the period 1970–1994. See Hagedoorn and Schakenraad (1994) for a further description of this data bank.

RESULTS

In order to test hypotheses 1 to 5 we applied ordinary least square regression (Table 1). We use linear regression as we expect a linear relationship between the

dependent and the independent variable. This is confirmed by the further analysis of scatterplots of the data that do not indicate a nonlinear pattern. Table 1 shows that our analysis does not generate a significant positive relationship between the level of technological sophistication of computer companies and their performance (hypothesis 1). For hypothesis 2 we do find the expected positive (significant) effect of technological specialization of firms on performance. Instead of the expected positive effect between the average market specialization and the average performance (hypothesis 3) we see a significant negative effect.

For the effect of externally acquired competences the findings appear to be generally negative and insignificant. The expected positive relation between related M&As and performance as suggested by hypothesis 4 is not be established. Also, the expected inverse relationship between the concentration of strategic technology alliances of companies in computers and the performance of companies as put forward by hypothesis 5 is not confirmed by our analysis.

From the group of control variables only size of companies seems to have a significant, albeit negative, impact on company performance. The effects of labor productivity and internationalization on performance turn out to be not significant.

Although we did not formulate hypotheses that go beyond main effects, we also explored some of the possible interactive effects between some of the variables, while retaining the control variables in the analysis. These interactive effects involve various combinations of the joint influence of technological specialization or sophistication with market specialization and related strategic alliances or M&As on performance. However, our research does not detect any significant interactive effect for the various combinations mentioned above.

DISCUSSION

The results of the analysis as described above seem to merit a more elaborate discussion. It appears that it is not necessarily the level of technological sophistication, indicating the depth of technological competences as such, but much more the degree of technological specialization, or the focus of technological skills, that appears to generate performance differentials between companies in a high-tech sector, such as the world-wide computer industry. This effect of specialized skills suggests that the cumulative and path dependent character of technological knowledge (Dosi, 1988; Nelson & Winter, 1982) seems to favor a strong and coherent technology base (Teece et al., 1994; Robin & Wiersema, 1995; Henderson & Cockburn, 1994). Although path dependency, at first sight, seems to be a handicap for rapid technological progress because it limits the options open to companies, it often turns out to be an essential condition for the effective development of a certain technology. Due to this particular character, technological change can rapidly expand technological frontiers while it is concentrated on a continuous process of relatively small changes in separate component parts with individual research projects focusing on improvements in small elements of the technology.

Given the importance of a specialized core knowledge base and considering previous research on diversification and market specialization (Wernerfelt & Montgomery, 1986; Varadarajan & Ramanujam, 1987, 1989; Capon et al., 1988; Harrison et al., 1993) we also expected to find a positive relation between the degree of

market specialization of companies and their performance. However, our findings indicate a negative relationship between the degree of market specialization and the performance of the companies in our sample. The combination of a specialized and coherent technology base and more diversified sales seems to suggest that the internally generated technological core competences can be applied beyond the traditional computer industry. This is in line with the increased recognition that technological convergence is one of the major driving forces of technological and economic developments in the international information technology industry (*Business Week*, 1992:69–71; Forester, 1993; Georghiou et al., 1986; Jonquieres, 1989; Duysters, 1996). For a very long time technological development in the various information technology markets has followed very distinct trajectories. Today, the basic design parameters that form the core of technological regimes (Georghiou et al., 1986) have become increasingly similar, not only in terms of the material properties but also with respect to the manufacturing process involved. Technological convergence is therefore gradually removing the sectoral boundaries between the various information technology industry segments. The pervasive effect of microelectronics and software can be found to drive convergence between virtually all the major information technology markets: consumer electronics, broadcasting, instrumentation, military electronics, software, data processing, and telecommunications. The ability to achieve economies of scope for many crucial products is founded on a common technological knowledge base, which also explains the higher level of performance of diversified firms in the international computer industry.

With regard to the relatively short-term effects of core competences, it is both the complex character of modern technology and the difficulties associated with the transfer of technological knowledge that seems to favor internal development instead of external competence appropriation through M&As or strategic alliances. Our findings suggests that strategic technology alliances cannot be considered as effective short-term vehicles for the acquisition of core competences, but instead should be used to complement endogenous capabilities in the long run (see also Hagedoorn 1993 & 1995; Harrigan, 1985; Mowery, 1988). Because of the globalization of markets, the increasing complexity of technologies, rapid technological changes, and the increasing costs of R&D, firms are no longer able to monitor all the technological developments that are important for their core markets. Strategic technology alliances enable companies to monitor several technological developments and at the same time, let them concentrate on a few, most promising, projects internally. If certain technologies turn out to be less successful, then alliances can be terminated with only a relatively small loss. The importance of alliances as monitoring devices is in accordance with the findings of Hagedoorn (1995) who found that only a small share of the strategic technology linkages of industry leaders are found in their core business.

In that context we can also point at a major problem associated with M&As that occurs if a company does not have an already sufficiently developed level of technological knowledge in a specific field. Then it turns out to be extremely difficult to absorb externally acquired knowledge into the existing technological core. It is often noted that a firm's absorptive capability is to a large degree dependent on the degree of knowledge in a specific field (Dodgson, 1989; Cohen & Levinthal, 1990; Levinthal, 1994). Therefore we might argue that if the core of a company's technology base is not sufficiently adapted to the new technology, the absorption

of newly acquired external technological knowledge within the existing technological core of a company is very difficult. This may also explain why many M&As are not very successful in generating short-term results in company performance.

CONCLUSIONS

It is only recently that the understanding of core competences and their effect on differences in the performance of individual companies has emerged as an important issue for empirical research. The current research is limited to one industrial sector, albeit a large and also a very strategic sector, but this concentration has also enabled us to systematically explore some of the basic questions related to core competences and company performance. Future research can focus on a larger number of industrial sectors and explore the usefulness of other possible indicators for understanding these core competences and their effect on performance. The development of both sector-specific indicators and a wider group of general indicators of core competences seems necessary to improve our understanding of the role that core competences play in determining inter-firm differences in high-tech industries.

A major conclusion for the current analysis of the role of core competences in this well-known international high-tech sector is that a specific set of endogenous technological core capabilities is needed to generate performance differentials. Technological specialization in terms of established and protected capabilities and a proven track record, for instance through a focussed patent position, appears more important than technological performance as such. Also, the external appropriation of competences, through M&As and strategic technology alliances, does not seem to be an easy short-term solution through which companies can quickly improve their existing capabilities and performance. Future research on the managerial aspects of M&As and alliances could in particular concentrate on the conditions under which both external forms of competence appropriation might generate specific contributions to the core capabilities of companies in high-tech sectors.

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NOTES

1. During our research we used both growth rates and average indicators for dependent and independent variables; however, the model reported in this paper performed substantially better than the other models in terms of overall explained variance. The period under investigation is to a large extent determined by the availability of reliable information through the Gartner Group which, unfortunately, stopped publishing these data after 1993.
2. Net income is often disturbed by accounting practices and is more sensible to temporary

gains and losses (due to e.g., selling of plants), interest payments etc. Other measures of performance are often more subjective and can be used by management to influence bottom-line earnings figures (Rees, 1990). During the analysis we also used other measures of performance such as profit divided by assets, asset turnover and growth of revenues but the inclusion of these dependent variables did not improve our analysis.

3. Based on previous research (Hagedoorn & Schakenraad, 1994) we assumed that companies from different regions of the Triad, i.e. the USA, Japan and Europe, will have different levels of profitability or at least different profit strategies that make it necessary to control for the national background of companies. However, it turned out during the statistical analysis that dummies for national differences were closely correlated with the structural and strategic differences of companies based in a specific region.

4. The Gartner group (1994) estimates that their sample of the leading 100 computer companies account for over 90% of the worldwide market. The firms in our sample cover more than 80% of the revenues in the Gartner Group sample. This implies that our sample accounts for nearly 75% of the total world computer market. For the other 43 companies, that make up about 15% of the worldwide market, we were not able to collect information on most of the variables analyzed in this study.

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ANNEX I LIST OF COMPUTER COMPANIES IN THE ANALYSIS

3Com	USA
Alps Electric	JAPAN
Amdahl	USA
Apple	USA
AST Research	USA
AT&T	USA
Canon	JAPAN
Cisco Systems	USA
Commodore	USA
Compaq	USA
CompuAdd	USA
Computervision	USA
Conner	USA
Control Data Systems	USA
Cray Research	USA
Data General	USA
Dell	USA
Digital Equipment	USA
Fujitsu	JAPAN
Groupe Bull	FRANCE
Hewlett-Packard	USA
Hitachi	JAPAN
IBM	USA
Intel	USA
Intergraph	USA
Lexmark	USA
Lockheed	USA
Mannesmann (DEC after 1990)	GERMANY
Matsushita	JAPAN
Maxtor	USA
Memorex-Telex	NETHERLANDS
Mitsubishi	JAPAN

Motorola	USA
NEC	JAPAN
Nihon Unisys	JAPAN
NTT	JAPAN
Oki	JAPAN
Olivetti	ITALY
Philips Group	NETHERLANDS
Quantum	USA
Racal	UK
Ricoh	JAPAN
Seagate	USA
Seiko Epson	JAPAN
Siemens	GERMANY
Silicon Graphics	USA
Sony	JAPAN
Storage Tech	USA
Stratus	USA
Sun Microsystems	USA
Tandem	USA
Tandy	USA
Texas Instruments	USA
Toshiba	JAPAN
Unisys	USA
Wang	USA
Xerox	USA